

Towards a universal biology: Is the origin and evolution of life predictable?

Abstract for: **Universal Biology:** Investigating Life as it *Must Be*

Sponsored by the Earth Life Science Institute, Tokyo August 2017

Lynn J. Rothschild, SST

NASA Ames Research Center

The origin and evolution of life seems an unpredictable oddity, based on the quirks of contingency. Celebrated by the late Stephen Jay Gould in several books, “evolution by contingency” has all the adventure of a thriller, but lacks the predictive power of the physical sciences. Not necessarily so, replied Simon Conway Morris, for convergence reassures us that certain evolutionary responses are replicable. The outcome of this debate is critical to Astrobiology. How can we understand where we came from on Earth without prophesy? Further, we cannot design a rational strategy for the search for life elsewhere - or to understand what the future will hold for life on Earth and beyond - without extrapolating from pre-biotic chemistry and evolution.

There are several indirect approaches to understanding, and thus describing, what life must be. These include philosophical approaches to defining life (is there even a satisfactory definition of life?), using what we know of physics, chemistry and life to imagine alternate scenarios, using different approaches that life takes as pseudoreplicates (e.g., ribosomal vs non-ribosomal protein synthesis), and experimental approaches to understand the art of the possible. Given that:

1. Life is a process based on physical components rather than simply an object;
2. Life is likely based on organic carbon and needs a solvent for chemistry, most likely water
3. Looking for convergence in terrestrial evolution

we can predict certain tendencies, if not quite “laws”, that provide predictive power. Biological history must obey the laws of physics and chemistry, the principles of natural selection, the constraints of an evolutionary past, genetics, and developmental biology. This amalgam creates a surprising amount of predictive power *in the broad outline*. Critical is the apparent prevalence of organic chemistry, and uniformity in the universe of the laws of chemistry and physics. Instructive is the widespread occurrence of convergent or parallel evolution, which suggests that under certain conditions similar solutions are arrived at independently.